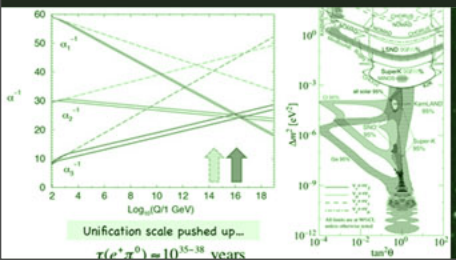
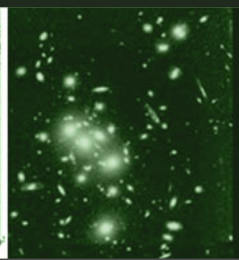
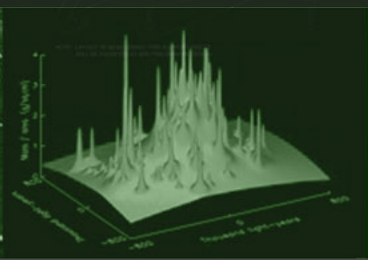
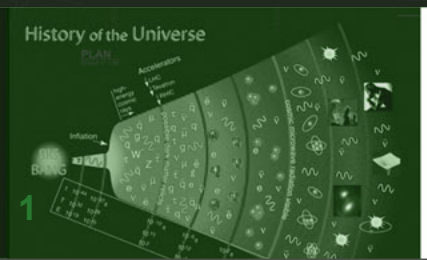
Update on Progress in Establishing Research Efforts at the Sanford Underground Research Facility

Kevin Lesko for SURF
LBNL
SURF Operations Head









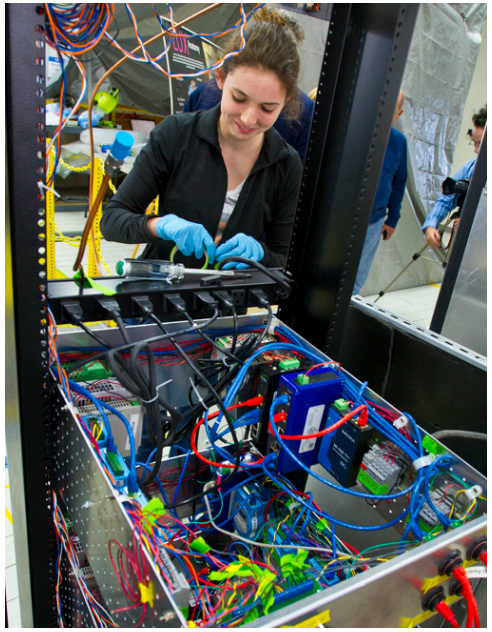
Sanford Underground Research Facility
SURF

Outline

- Progress Establishing the SURF Facility
- Current Science Program and Projects
- Additional Proposed Research Efforts
- Site Characterization Efforts and Refinement of Facility Operations
- Summary

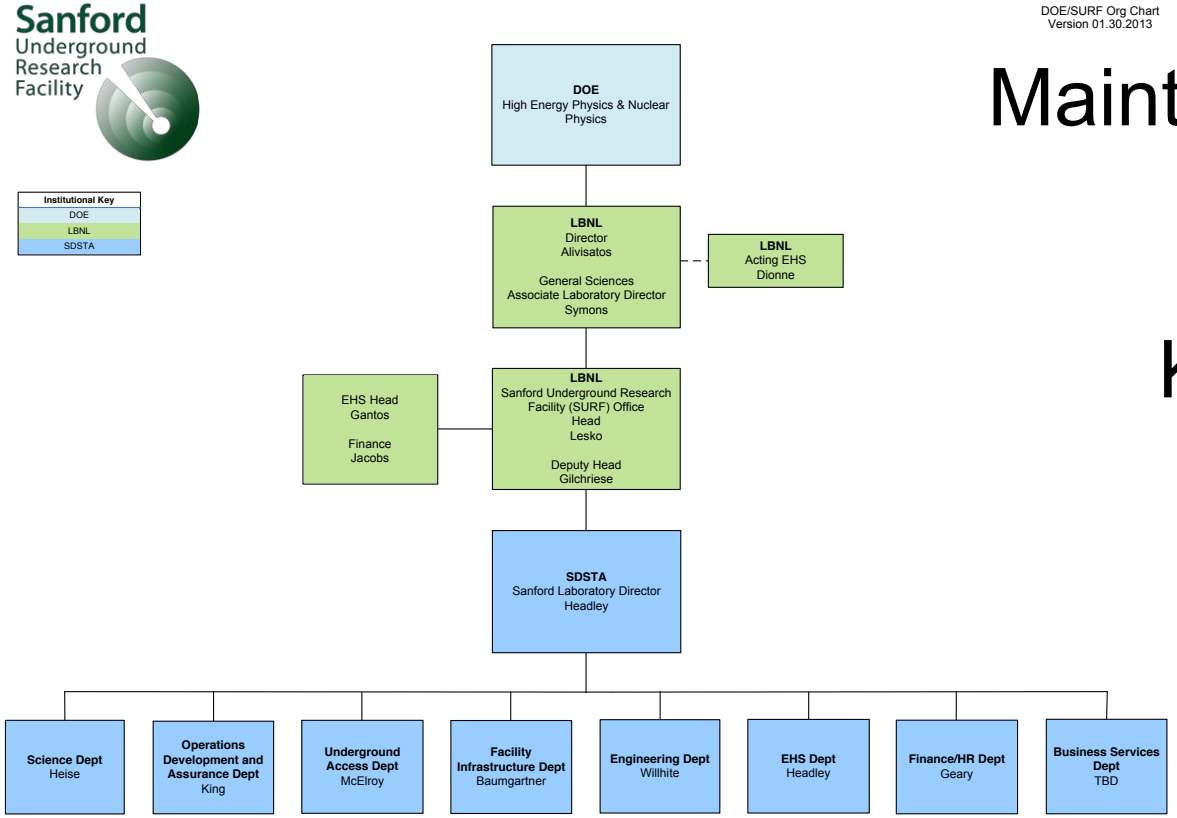
What is the current status of SURF?

- FY 2012
  - Facility
    - Facility Dewatered below the 6000 foot level Complete ✓
    - Yates promoted to primary access Complete ✓
    - Davis Laboratory Outfitting Complete ✓
    - Ross Shaft Rehab - design completed and reviewed, rehabilitation Initiated (still provides secondary egress)
  - Science
    - LUX Dark Matter, MAJORANA DEMONSTRATOR Neutrinoless Double Beta Decay, & CUBED - Installing ✓
    - LBNE 10 kt surface-deployment Conceptual Design Completed ✓
    - Proposals for DIANA, LZ, LBC under review, some funding announced
- FY 2013 - 15
  - Facility
    - Ross Shaft Rehab continues, first ~ 400 feet done.
  - Science
    - LUX and MJD anticipated to be taking data
    - LZ R&D funded in the US and Great Britain ✓
    - LBNE - CD1 approved December 2012 ✓
    - Site-visit by DIANA Project ✓



DOE-funded Facility and Organization

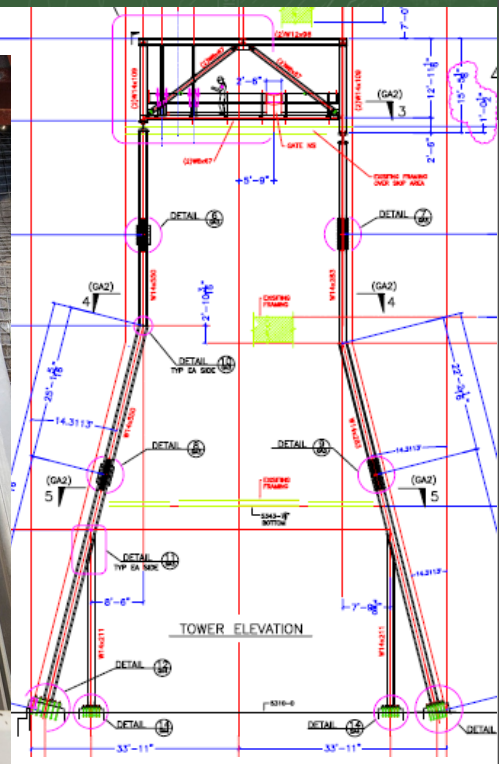
With the Termination of NSF's support of DUSEL in 2011 and with DOE assuming responsibility in FY12, Lawrence Berkeley National Lab provides management and oversight of SURF Operations, contracting with SDSTA



Maintaining facility operations, engineering, science, & EH&S functions.
Key staff transferred from NSF to DOE support at LBNL/UCB and SDSTA

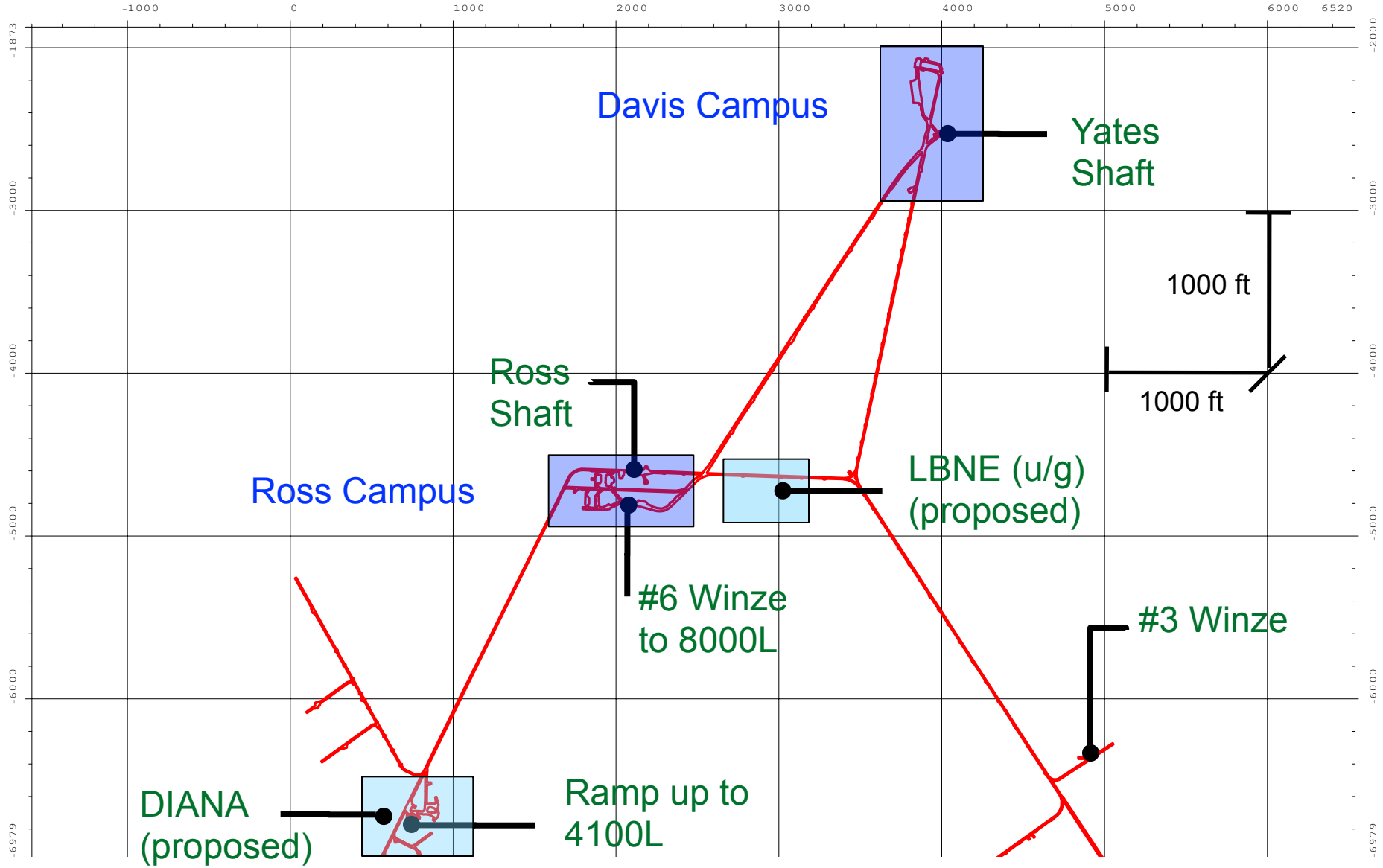
Providing Redundant, Safe Access Underground

- Yates Shaft (wood furnishing)
  - Rope Dogs *Installed* (emergency brakes)
  - Shaft Inspection and Maintenance Activities *continue*
- Ross Shaft (steel furnishing)
  - Rehab of the Shaft *Initiated*
    - New Steel Furnishings and Ground Support
  - *Completed* ~450 feet so far
  - Completion anticipated in FY2016, timed to support LBNE and DIANA



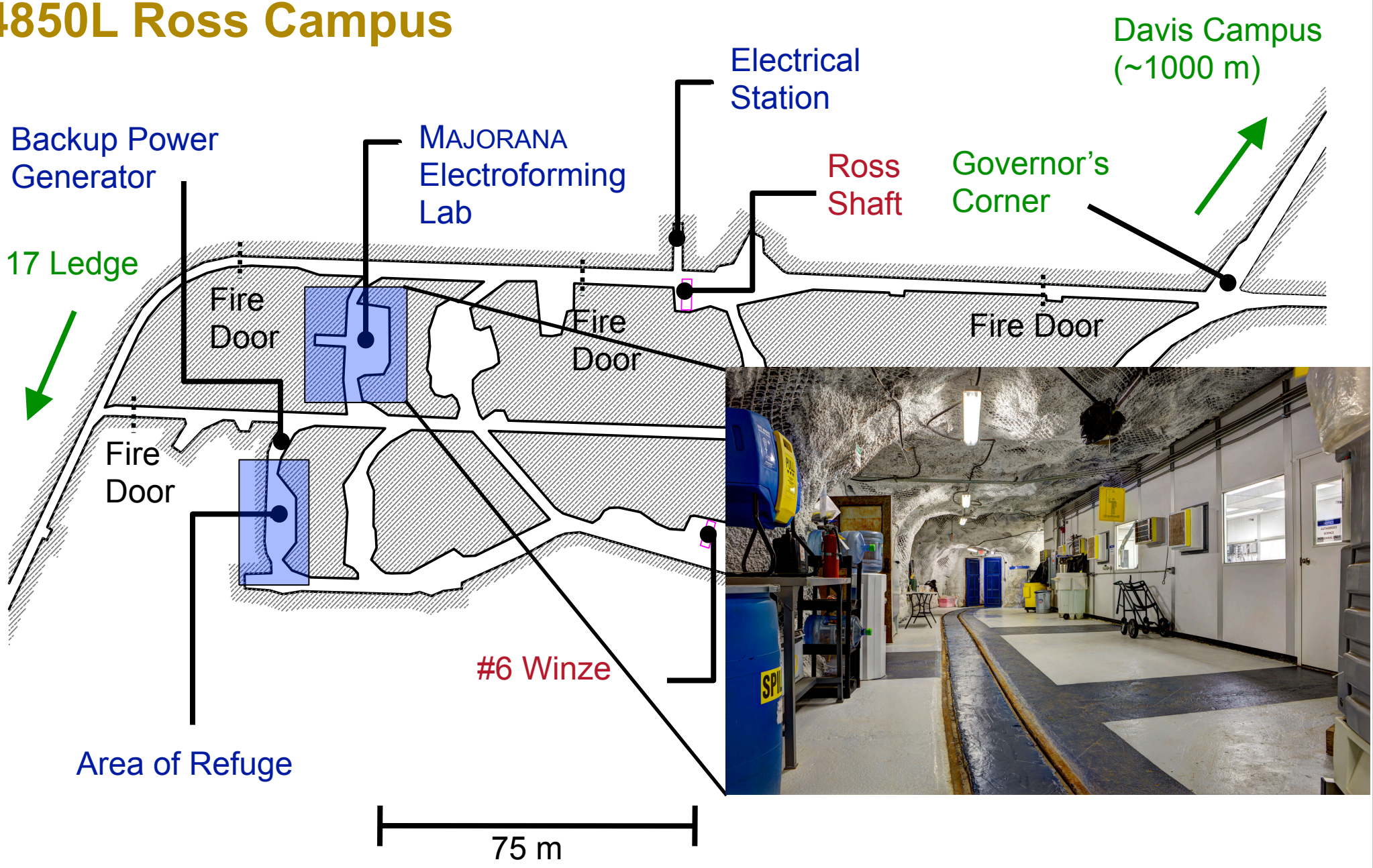
SURF Science Infrastructure: 4850L

4850L Sanford Laboratory



SURF Science Infrastructure

4850L Ross Campus

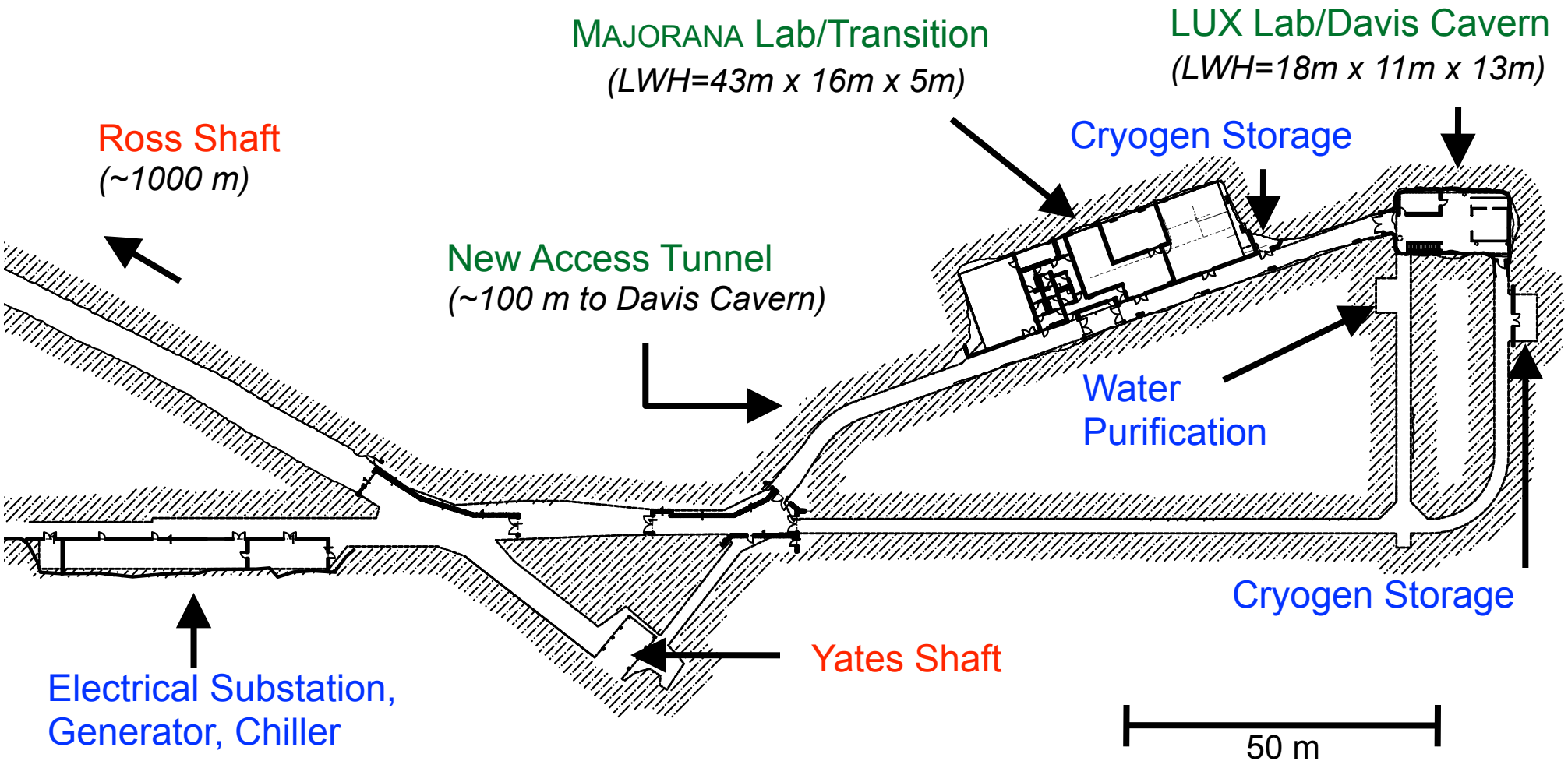


4850L Area of Refuge

- Occupancy: 72 people – 96 hours
- Oxygen (bottled air and scrubbers)
- Water
- Communications (redundant)
- Supplies
- Rest-rooms
- Airlocks
- Areas for (Physics) Discussions
- Interesting Geology

SURF Science Infrastructure

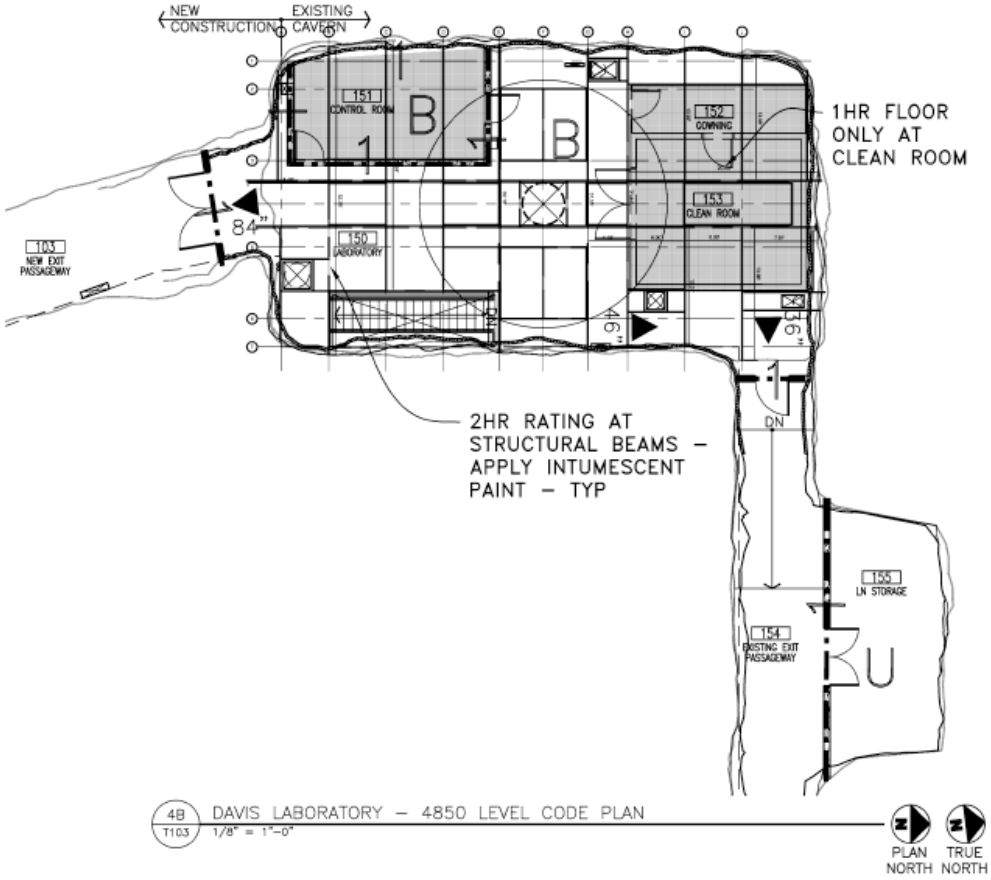
4850L Davis Campus: 29,402 ft² (Total) / 9,979 ft² (Science)



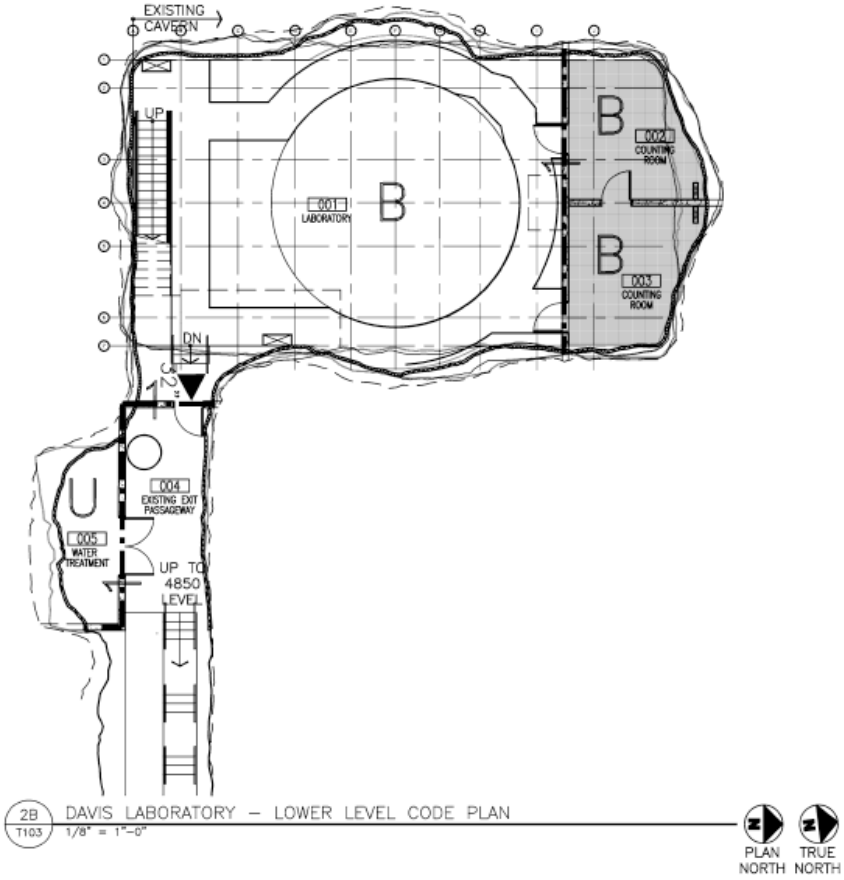
SURF Science Infrastructure

4850L Davis Campus: 2,732 m² (Total) / 927 m² (Science)

Davis Cavern Upper



Davis Cavern Lower

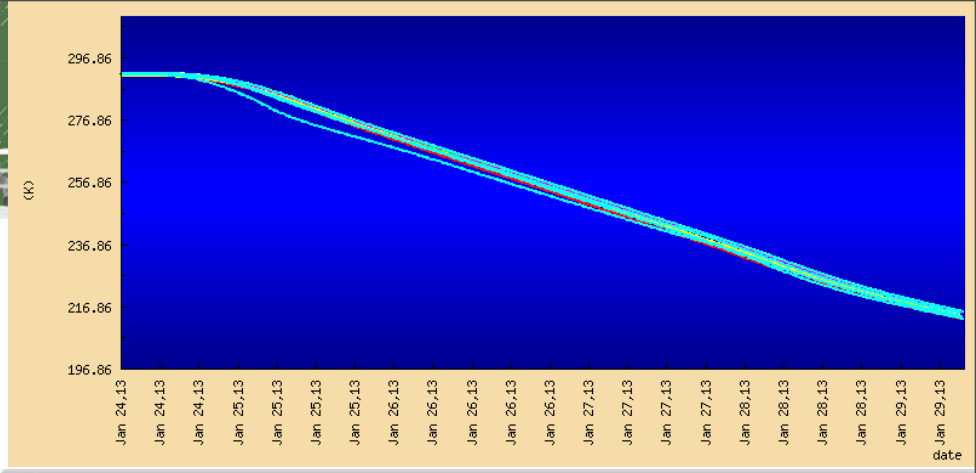


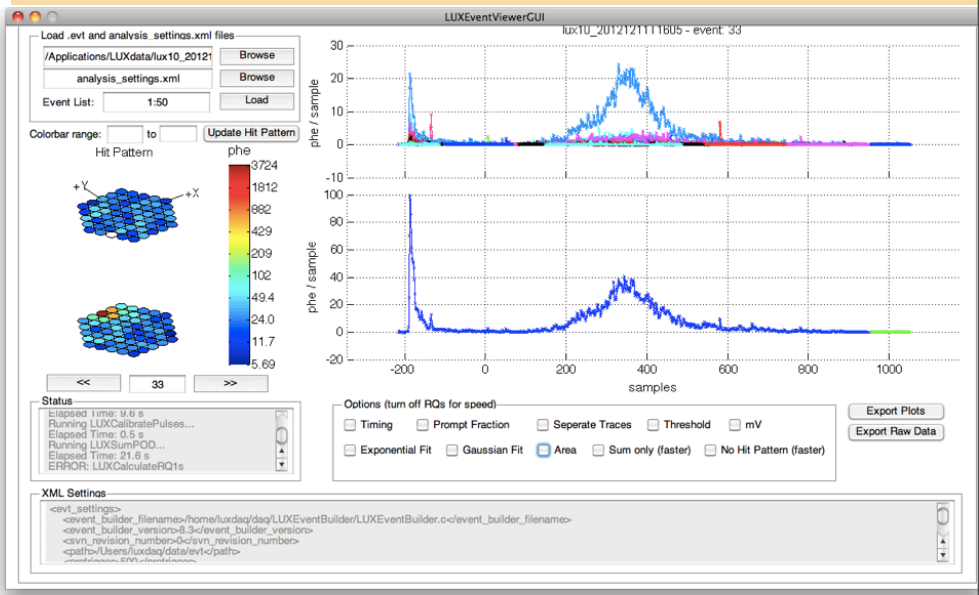
Davis Campus

- Outfitting of the Davis Campus Completed May 2012 (~4300 mwe)
  - HVAC, HEPA filtered air, Utilities, Transportation and access, ...
  - Experiment specific infrastructure
    - Clean rooms
    - Water tank
  - Science and EH&S Support Programs
- *Eur.Phys.J.Plus (2012)* ***127****:114*

Current Physics Program

- Large Underground Xenon (LUX) – Dark Matter
  - 370 kg dual phase direct detection dark matter detector
  - detector installed, filled and commissioning
- MAJORANA DEMONSTRATOR – Neutrinoless Double Beta Decay
  - 40 kg ^{nat,76}Ge, vacuum cryostat
  - assembling first strings of ^{nat}Ge and ^{76}Ge point-contact detectors
- CUBED – Low Background Assay and Advanced Detectors and Materials
  - Preparing to install

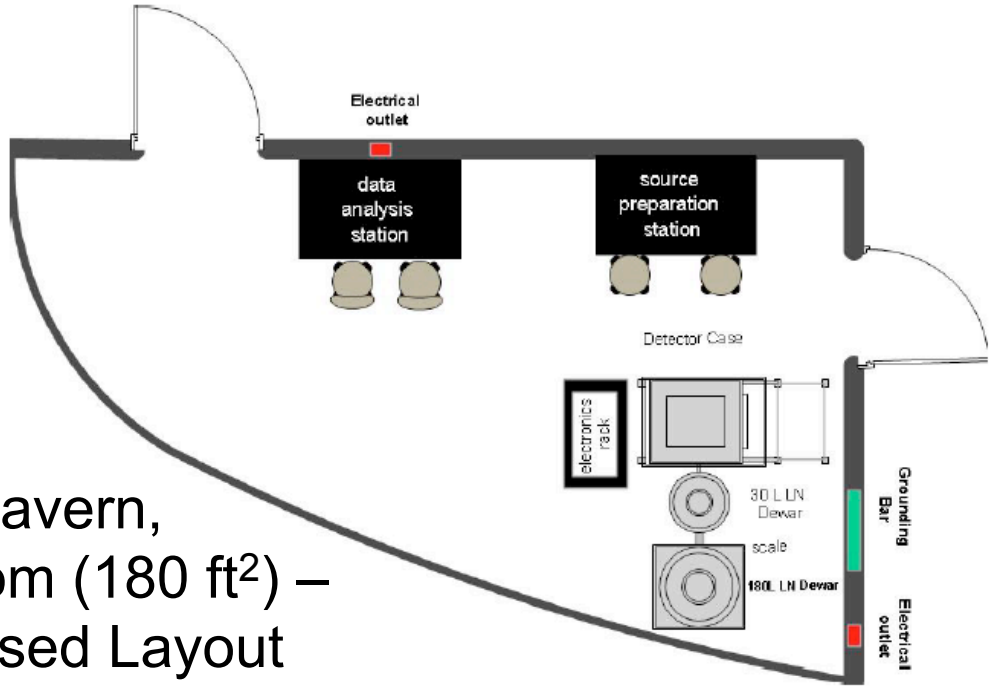




Low-Background Counting

- CUBED/USD HPGe:
  - Currently operating on surface at USD
  - Will be installed at 4850L Davis Campus, operational in 2013
  - Expected sensitivity 0.1 – 0.01 ppb for U/Th
- Future:
  - Looking for opportunities to host/acquire several detectors with various sensitivities

CUBED HPGe System at USD



Lower Davis Cavern, Dedicated Room (180 ft^2) – CUBED Proposed Layout

Current Science Program

Physics
- **LUX-350** – *Dark Matter*
- **MAJORANA DEMONSTRATOR** – *0νββ*
- **CUBED** – *Low-Bkgd Counting* (possibly Crystal Growth in future)
- Bkgd Characterization – *μ,n,γ,Rn* [1,2]
- DIANA – *Neutron backgrounds*
- LBNE – *Cleanliness tests*
- DUGL – *Seismic characterization* [3]

Geology
- GEOX™ – *Optical fiber applications, tiltmeters for deformation* [4]
- Hydro Gravity – *Local gravity for water tables, densities*
- PODS – *Petrology, ore deposits, structure*
- Transparent Earth – *Seismic arrays*

Biology
- Biodiversity – *BHSU, SDSMT* [5,6]
- Lignocellulose – *SDSU*
- Biofuels – *SDSMT* [7,8,9]
- Bioprocessing R&D – *SDSMT*
- Syngas/Biofuels – *SDSMT*

Engineering
- None currently, but interest from geothermal, Xilinx
- *Previous include:*
  - *Signal Propagation*
  - *Submersible*

Other (Site Selection Only)
- Cummingtonite – *Geology (NSSGA)*
- Vertical Array – *Geophysics (SJSU)*
- THMCB – *Geology (NSF S4)*
- Fracture Group – *Geology (NSF S4)*
- EcoHydro Group – *Geology (NSF S4)*

Total Active = ~16 groups
(Plus Others)

Peer-reviewed publications denoted by [ ]

Science Program by Level

16 Active Groups Plus Others; Bold Names are Active Installations

Surface
- LUX-350 – *Detector assembly, IT*
- **LBNE** – *Cleanliness tests*
- Bkgd Char – *Gamma, muon, Rn*
- **Microclimate/SUL** – *Temp, precip*
- Vertical Fac – *Mag field, Ross/Yates*
- **Hydro Gravity** – *Site markers*
- **PODS** – *Core archive*
- **Transparent Earth** – *Core archive*

300L
- **DUGL** – *Low-freq seismometer*
- Bkgd Char – *Rn*
- Signal Prop – *EM prop in drifts*
- Biodiversity – *Baseline samples*

800L
- **DUGL** – *Low-freq seismometer*
- Bkgd Char – *Gamma, muon, Rn, neutron, Pb storage*
- CO_2 Sequestration – *Env monitor*
- MAJORANA – *Pb, Cu storage*
- PODS – *Geologic mapping*

1250L
- Microclimate/SUL – *Temp, humidity*
- **Bkgd Char/SUL** – *Rn*

1700L
- Lignocellulose – *Bio samples*

2000L
- **Transparent Earth** – *Seismo/tilt (x2)*

2000L (cont)
- **GEOX™** – *Tiltmeters (x3), climate*
- **DUGL** – *Low-freq seismometer (x2)*
- Bkgd Char – *Gamma, Rn, muon*
- Biodiversity – *Seeps, fungus (multi)*
- CO_2 Sequestration/**SUL** – *Env monitor*

2600L
- Microclimate/SUL – *Temp, humid (x2)*

3350L
- **Utah/SUL** – *Extensometers*

4100L
- **DUGL** – *Low-freq seismometer (x2)*
- **GEOX™** – *Optical extens, temp*
- **Transparent Earth (x2)** – *Seismo/tilt*
- **Biology (x2)** – *Seeps, soil*
- DIANA – *Neutron background*

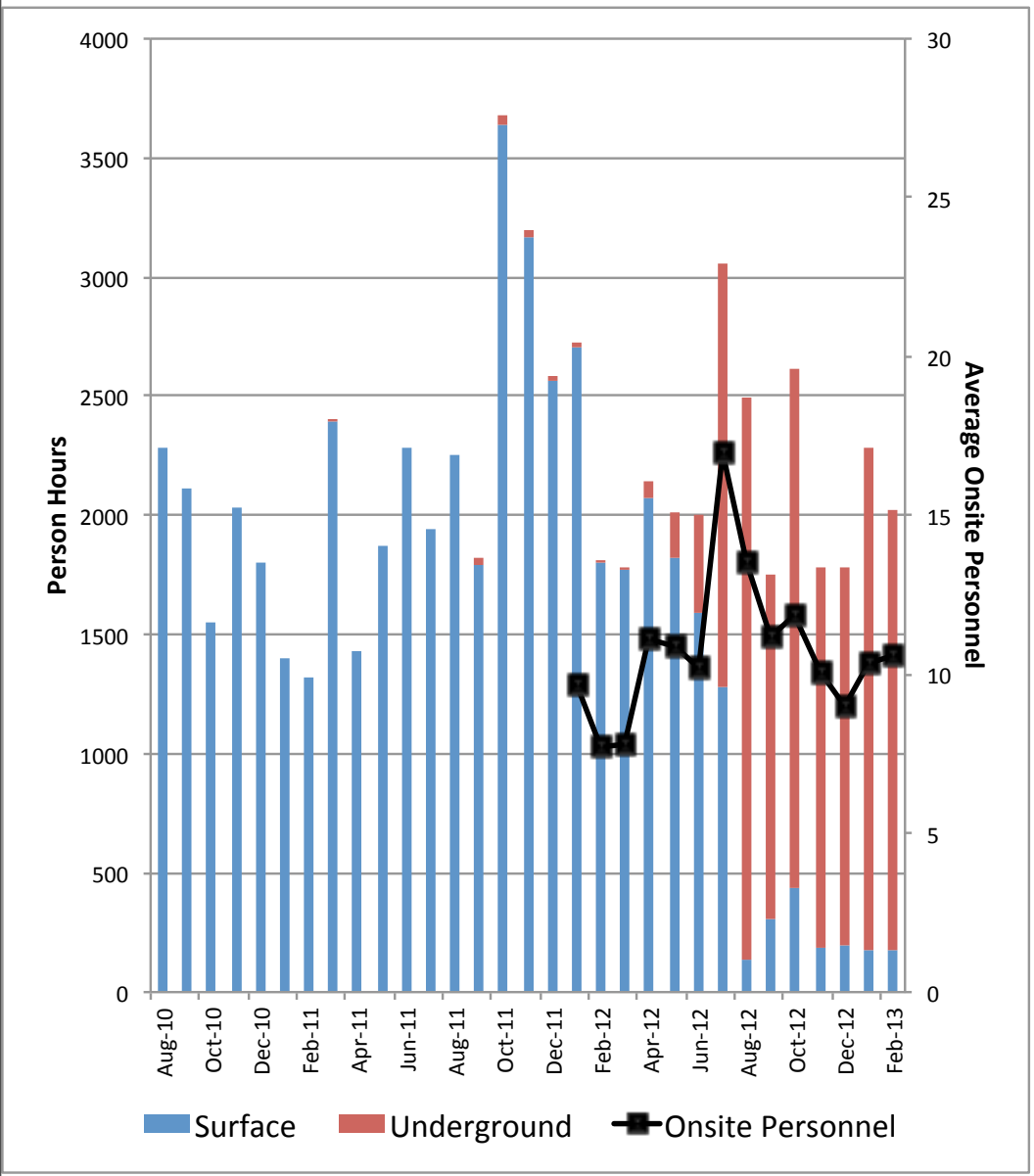
4550L
- Biofuels – *Soil samples*
- GEOX™ – *Hydrology*
- Bkgd Char – *Gamma, Rn*
- Bio-Manifold – *Pump water*

4850L
- **MAJORANA** – *Cu eforming, Pb, 0νββ*
- **LUX-350** – *Dark matter*
- GEOX™ – *Hydrology, tiltmeters*
- CO_2 Sequestration – *Env monitor*
- Biology (x6) – *Seeps, soil, core holes*
- Bkgd Char/**SUL** – *Rn, gamma, x-ray*

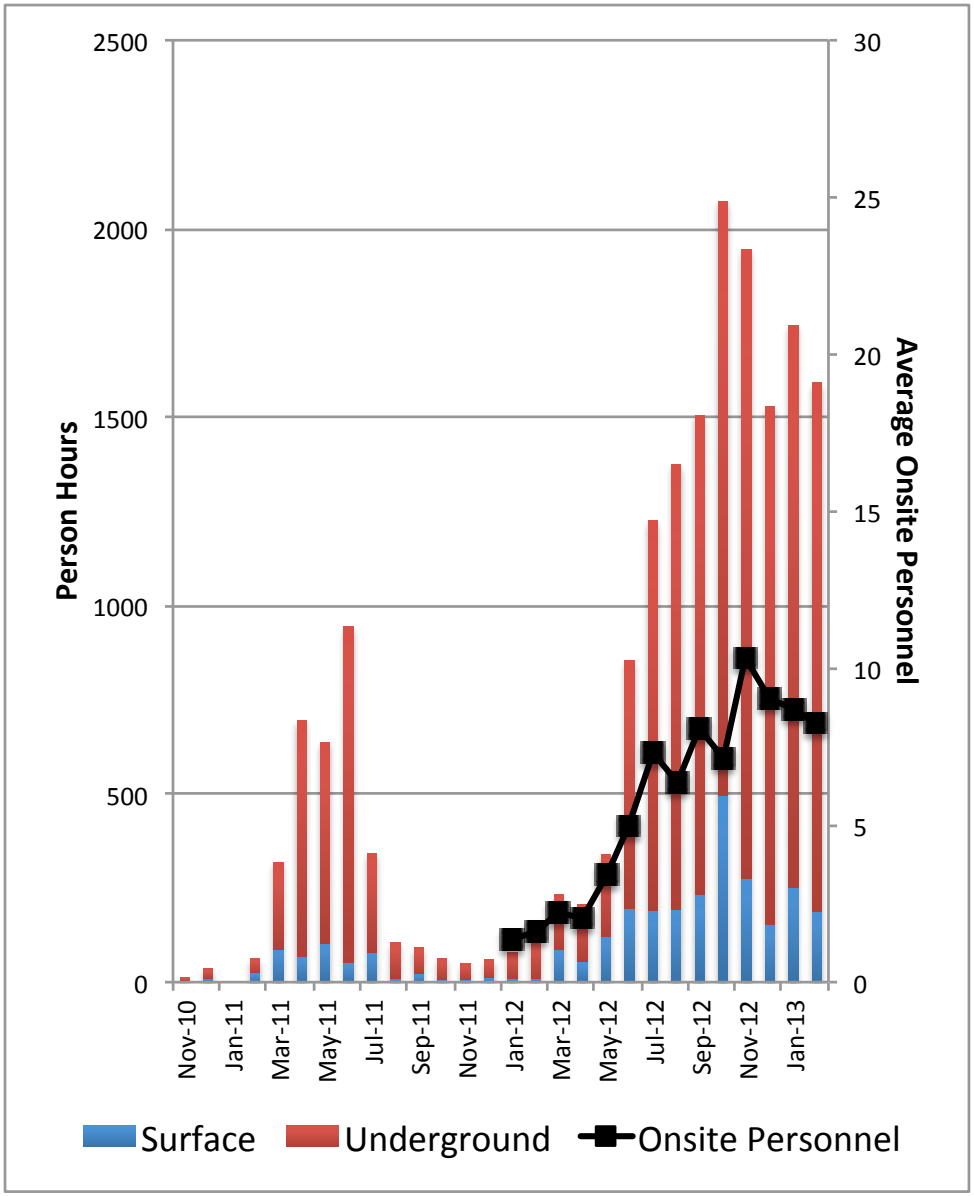
5000L
- **Biofuels** – *Soil, water samples*

Major Collaboration Researcher Effort On-site

LUX

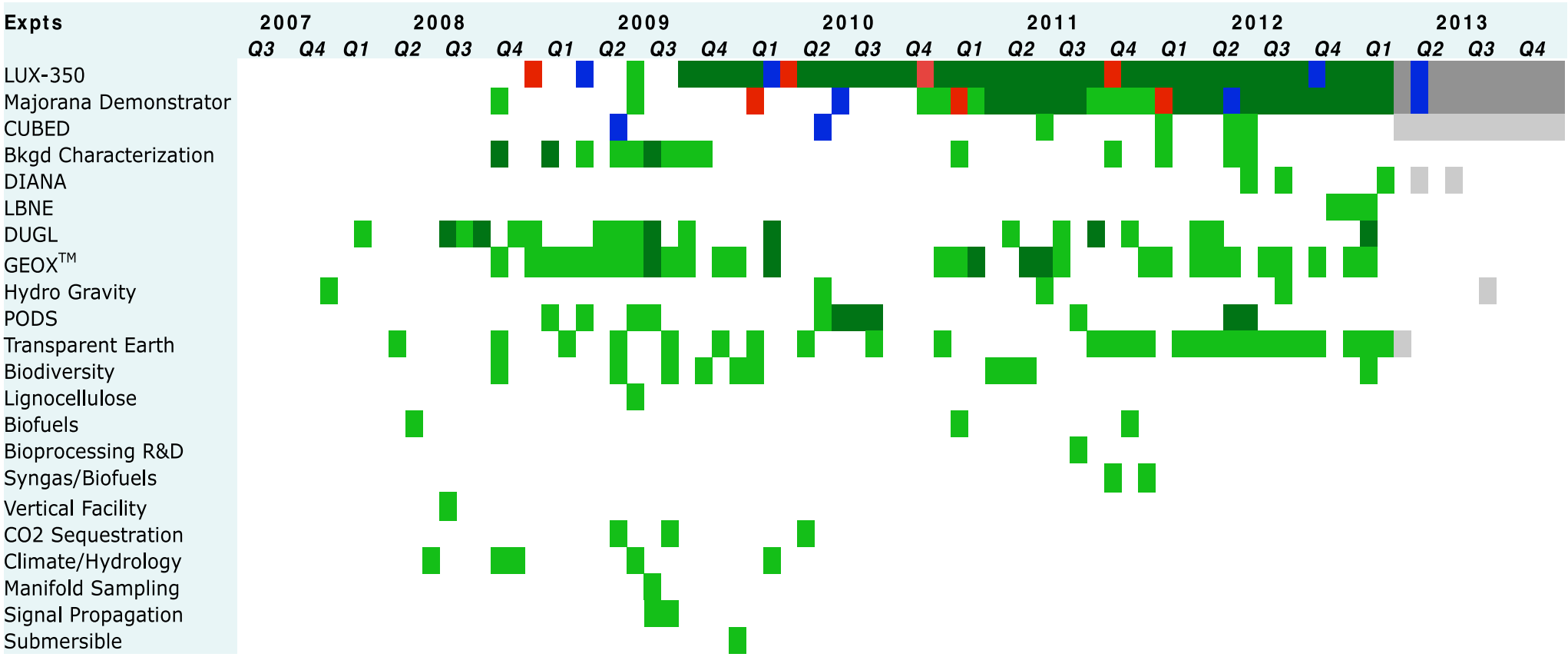


MAJORANA



SURF Current Science Program

Onsite Research Activities: ~100,000 Hours Since 2007



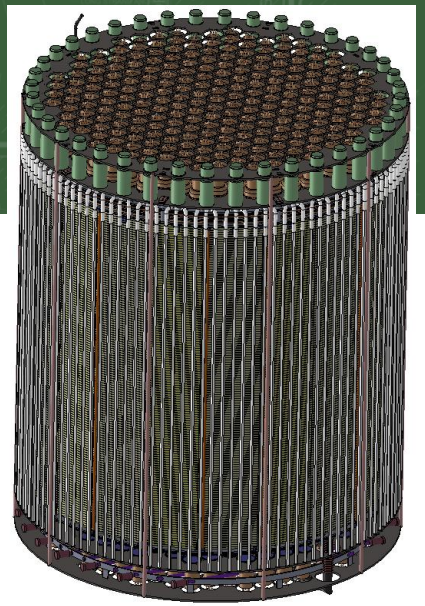
Research activity (dark > 100 hours)
External Reviews
Collaboration Meetings

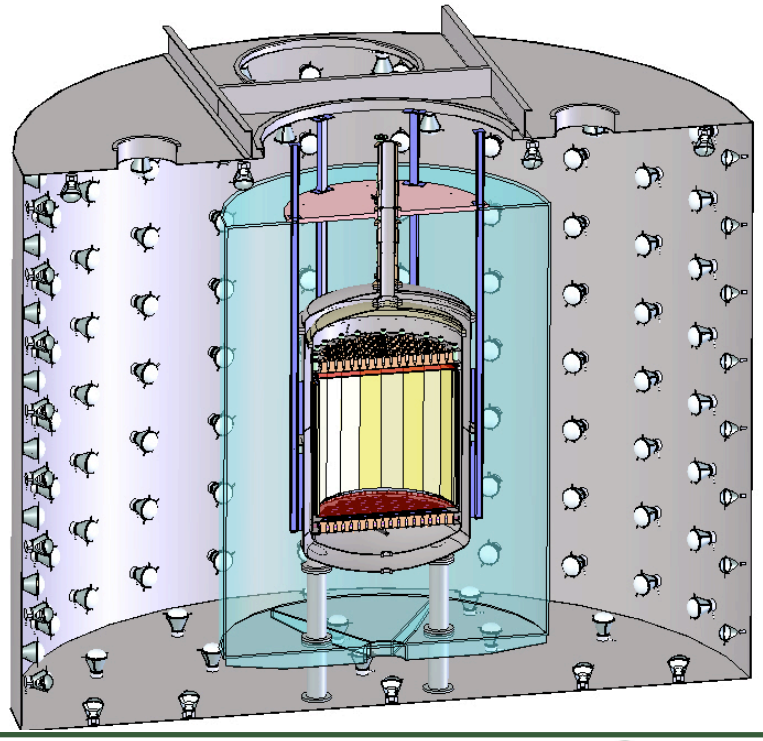
Proposed activity (dark > 100 hours)

Plans for the future: 2nd Generation Dark Matter Experiment

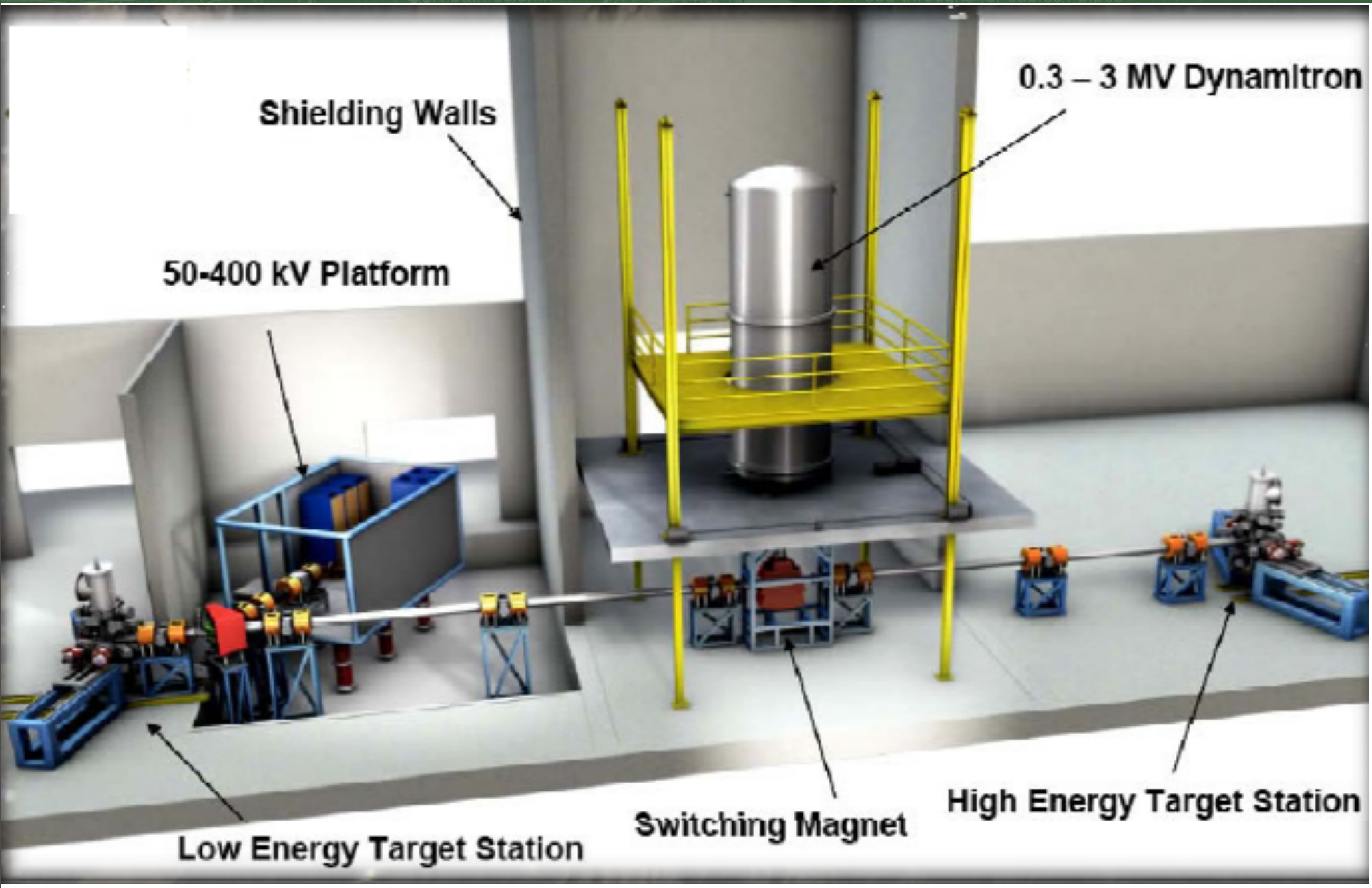
LZ (LUX-Zeplin)

- 2-phase Liquid Xenon detector
- ~7 tonnes Xe
- ~20 x LUX with improved background rejection
- Liquid scintillator veto outside Xe detector
- Uses existing water tank at 4850L Davis Campus at SURF
- Formed from LUX and Zeplin collaborations: US and UK funding in place for R&D and design (Dec 2012)



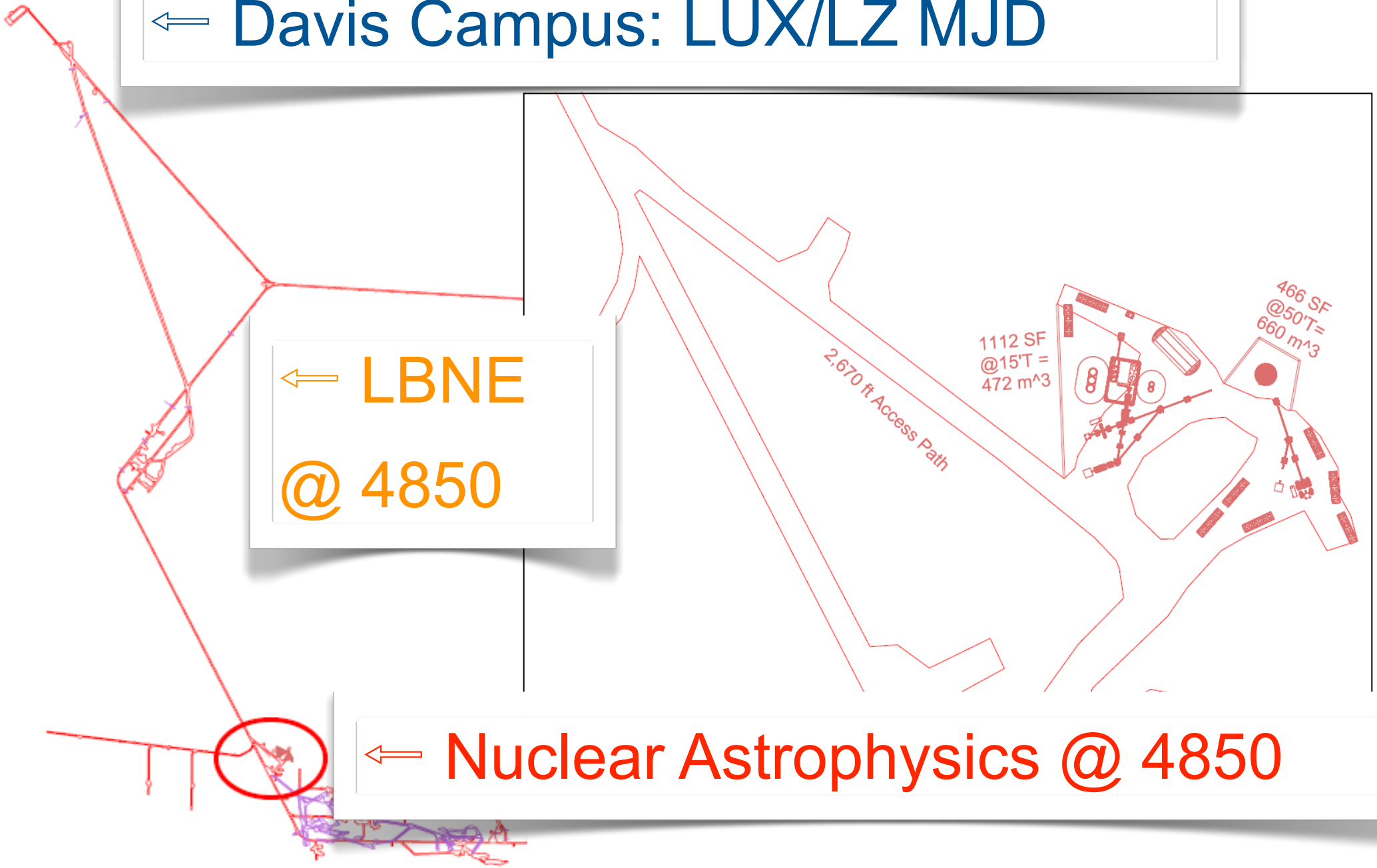


Nuclear Astrophysics: DIANA



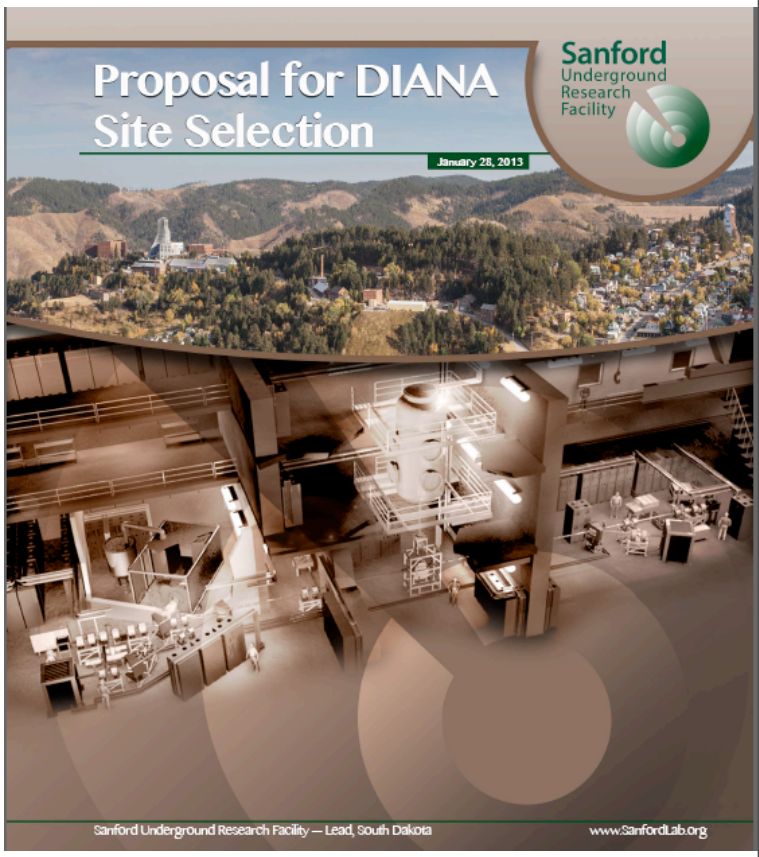
DIANA at 17 Ledge

⇦ Davis Campus: LUX/LZ MJD

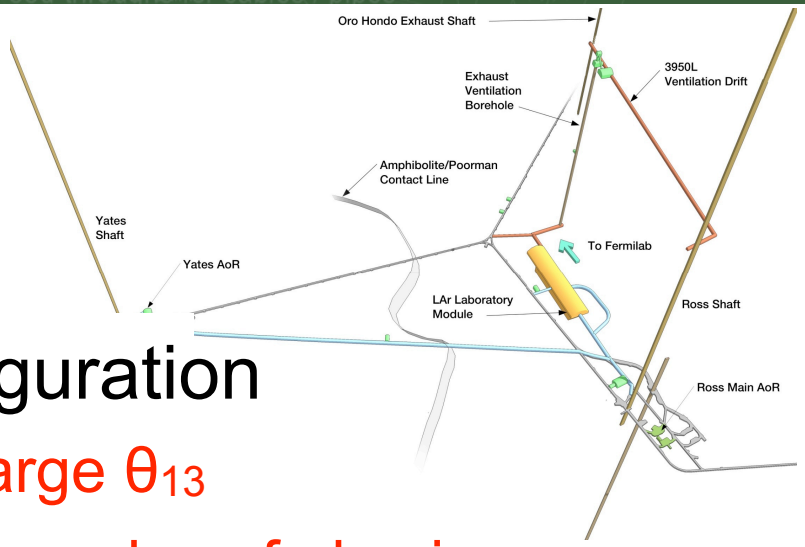


DIANA: Response to Request For Info

- 28 January response to RFI
- Productive site visit 6 February
- Site Selection decision anticipated soon



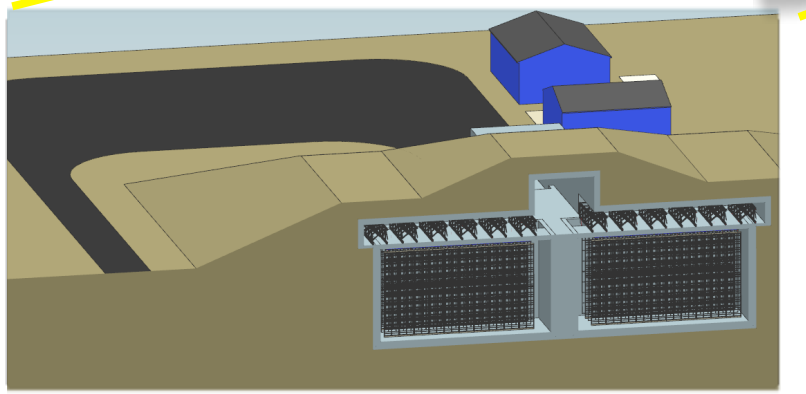
Long-Baseline Neutrino Experiment: Determining Mass Hierarchy and CP Violation



- Originally designed as 35 kt Liquid Argon at the 4850L
- ~$1.5 to $2 B
- Office of Science asked for a reconfiguration
  - phased program - planning validated by large θ_{13}
  - significant physics results at each step - decades of physics
  - first step targeted at $700 to $800M
- Steering committee considered ~17 options, and advanced three: http://www.fnal.gov/directorate/lbne_reconfiguration/index.shtml
  - 30 kt LAr on the surface at Ash River
  - 15 kt LAr underground at Soudan 2350 feet
  - 10 kt LAr on the surface at Homestake - **preferred approach**, stronger physics, self-reliant program, upgradable, utilizes uniqueness characteristics to establish a world-leading program

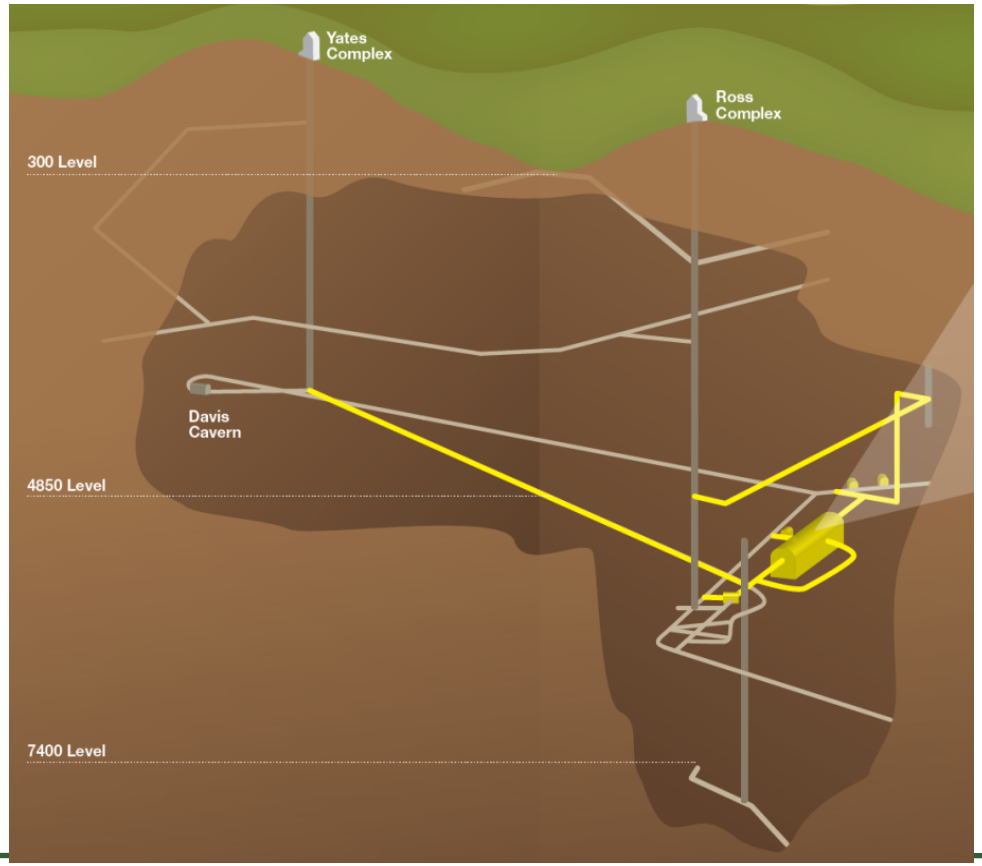
Long-Baseline Neutrino Experiment

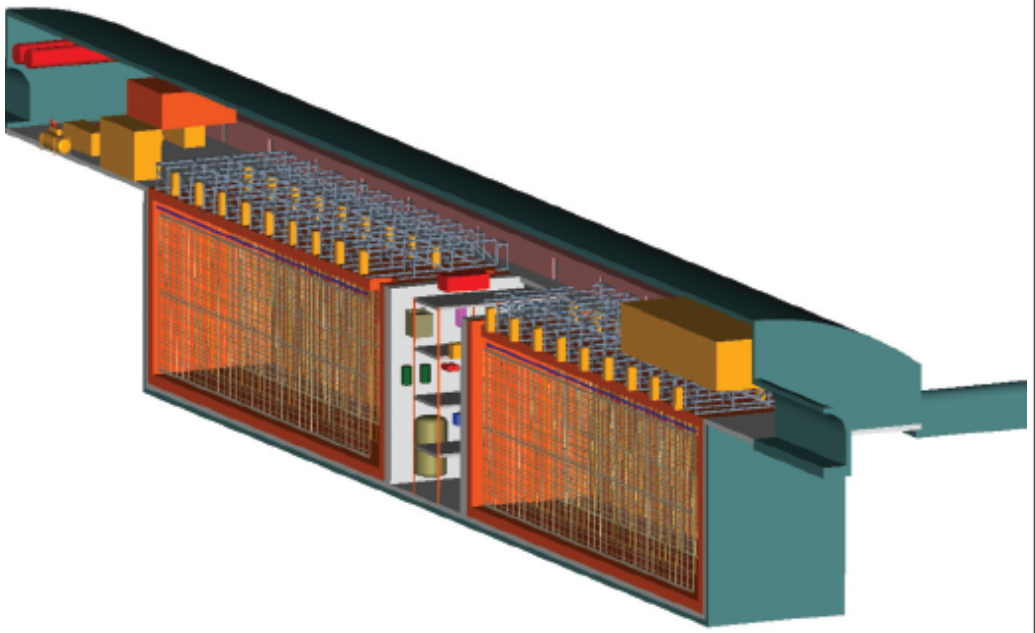
- Office of Science accepted LBNE reconfiguration plan (6/12)
  - 10 k-ton (fiducial) LAr on the surface, new FNAL beam-line
  - Underground Options with new funds identified before CD2
  - Conceptual Design Review Oct. 2012
    - CDR completed, EA work initiated, MOUs drafted
  - **CD-1 Signed 10 December 2012**
  - Preliminary Design ~ 2015-6



Underground LBNE Option

- Significant Design Work Completed for DUSEL
  - Ventilation Issues understood
  - Conceptual Designs developed
- Updated-Cost Estimate Nearing Completion





SURF R&D Space – Surface

- Surface Laboratory:
  - *190 m² lab space (lower 3 levels not fully developed)*
  - *Cleanroom (~37 m² including anteroom, 3-m ceiling, Class ~1000)*
  - *Water tank (~25 m³, ~3-m diameter)*
  - *Communications, network*
- *Other options possible, but may require some preparation/rehab*

Main area, hatch covers opening to water tank

LBNE cleanliness tests (Bai-SDSMT)

SURF R&D Space – Underground

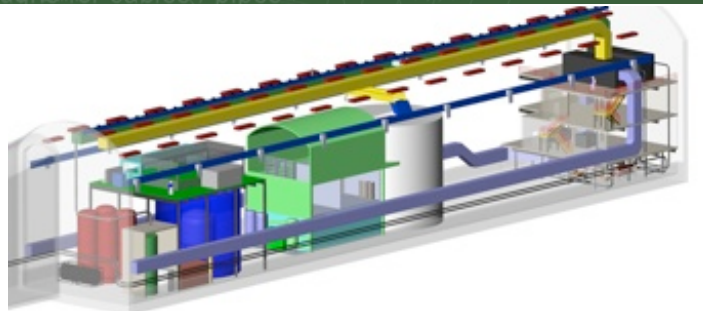
- Davis Campus and Vicinity:
  - *Inside Davis Campus clean space, Lower Davis room: ~17 m² (14' ceiling height)*
  - *Two cutouts outside clean space: ~33-50 m² (with 12' avg ceiling height)*
- *Working to formalize these and other options for the community*

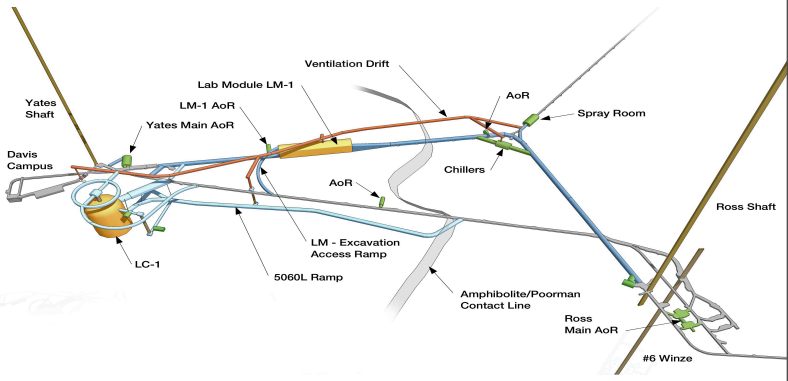
Near Davis Campus entrance, sprinklers, concrete floor, power/network installed

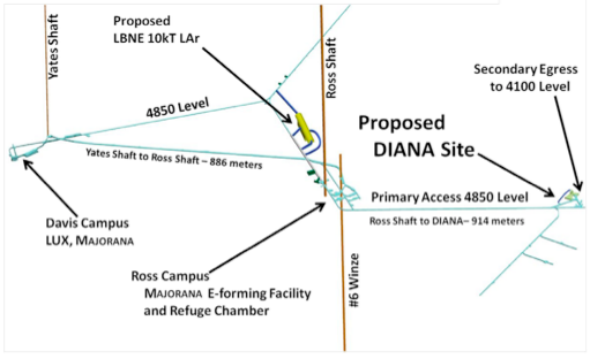
Near decline to Water Purification room, less developed, services easy to install

Future Plans and Road Maps

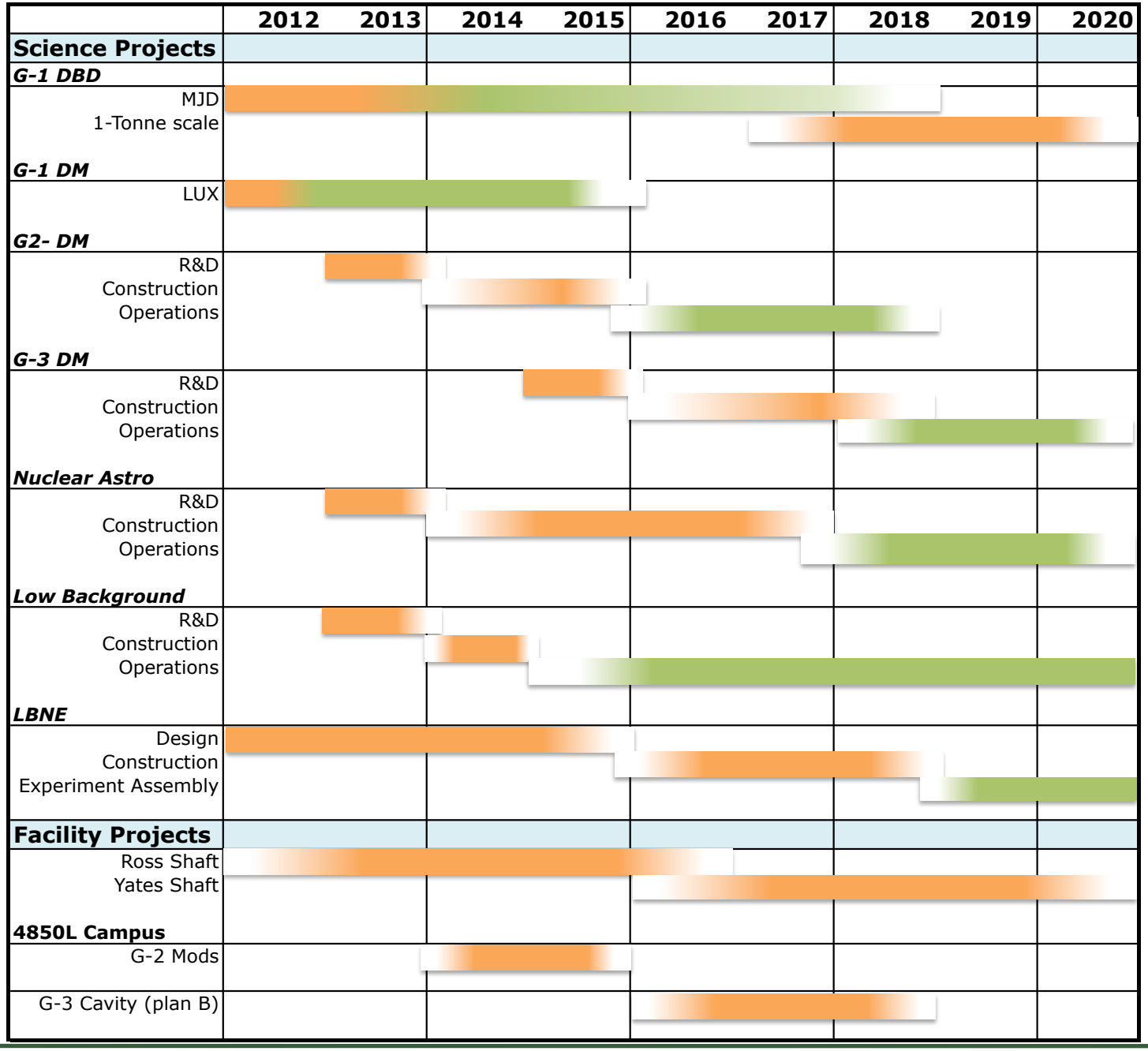
- Dark Matter
  - G-2 efforts
    - LZ in the Davis Campus
  - R&D
    - some limited space available, open for discussions
  - G-3 effort
    - May require a new Lab Module, have advanced designs and estimates
- Neutrinoless Double-Beta Decay
  - R&D
    - some limited space available, open for discussions
  - 1-tonne Experiment
    - May require a new Lab Module, have advanced designs and estimates
- Nuclear Astrophysics
  - Response to DIANA RFI (29/1/2013) – mostly existing space
- LBNE, Proton Decay, Astronomical Neutrinos
- Low Background Counting/Assay/Materials
  - CUBED+ (LBC)
  - Existing space could be outfitted to handle ~ 6 or 8 counting stations
  - MJD TCR capable of producing substantial ultrapure Cu
  - AARM-style facility may require new laboratory module







Time-lines for this Decade



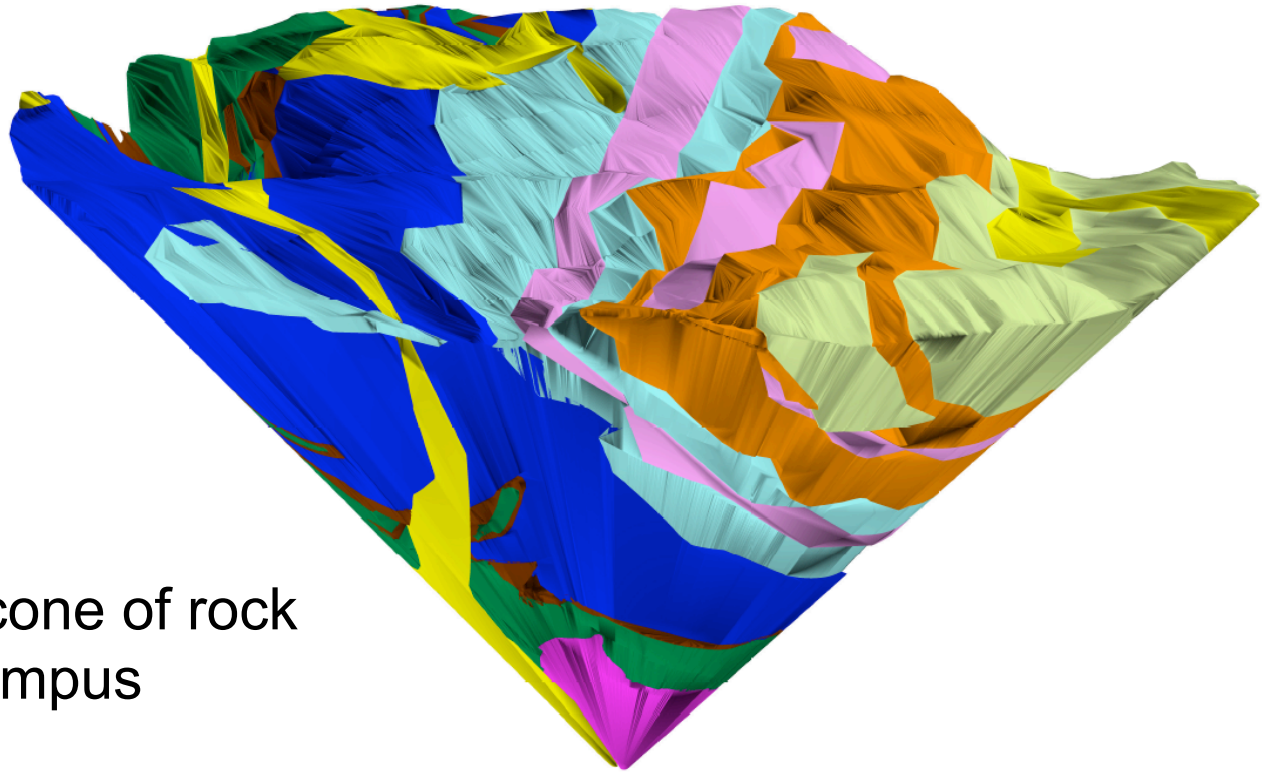
Current Involvement of International Scientists

- LUX ~ 88 members (LZ comparable or larger)
- MJD ~ 91 members
- CUBED ~ 10 members
- BGEs $\lesssim$ 50 members
- LBNE ~ 347 members and growing
- *DIANA ~ 25 members*

- *Collaborations routine hold collaboration meetings at SURF*

SURF Geology Model

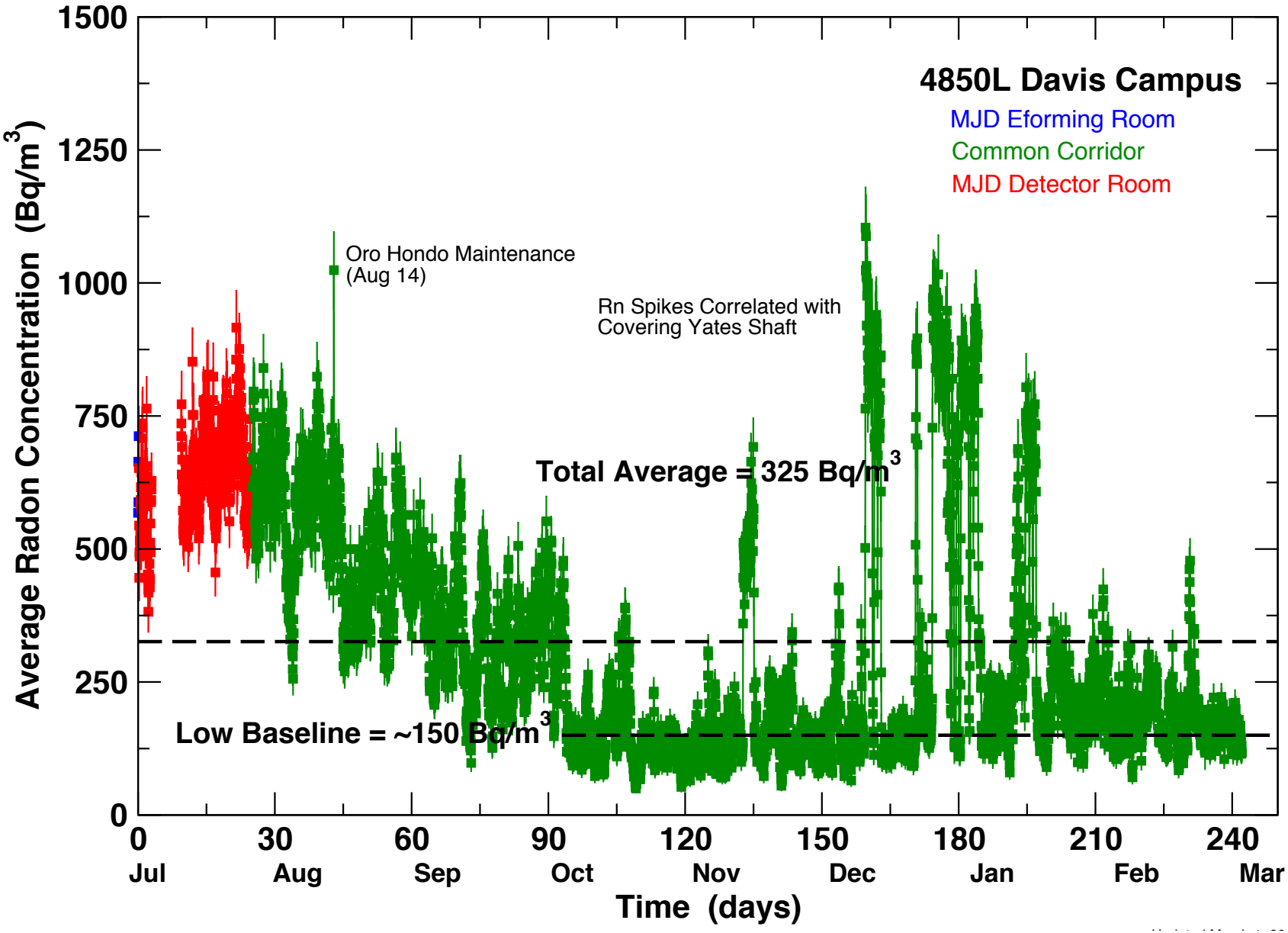
- 3D model of seven main rock formations
- Detailed surface topology
- Compiling rock geo-chemistry and density data from variety of sources
- Working to increase model extent (~99% muon flux)
- Slicing cone to give geology as function of angle



Representation of 3D cone of rock above 4850L Davis Campus

Site Characterization Studies

https://docs.sanfordlab.org/docushare/dsweb/View/Wiki-86



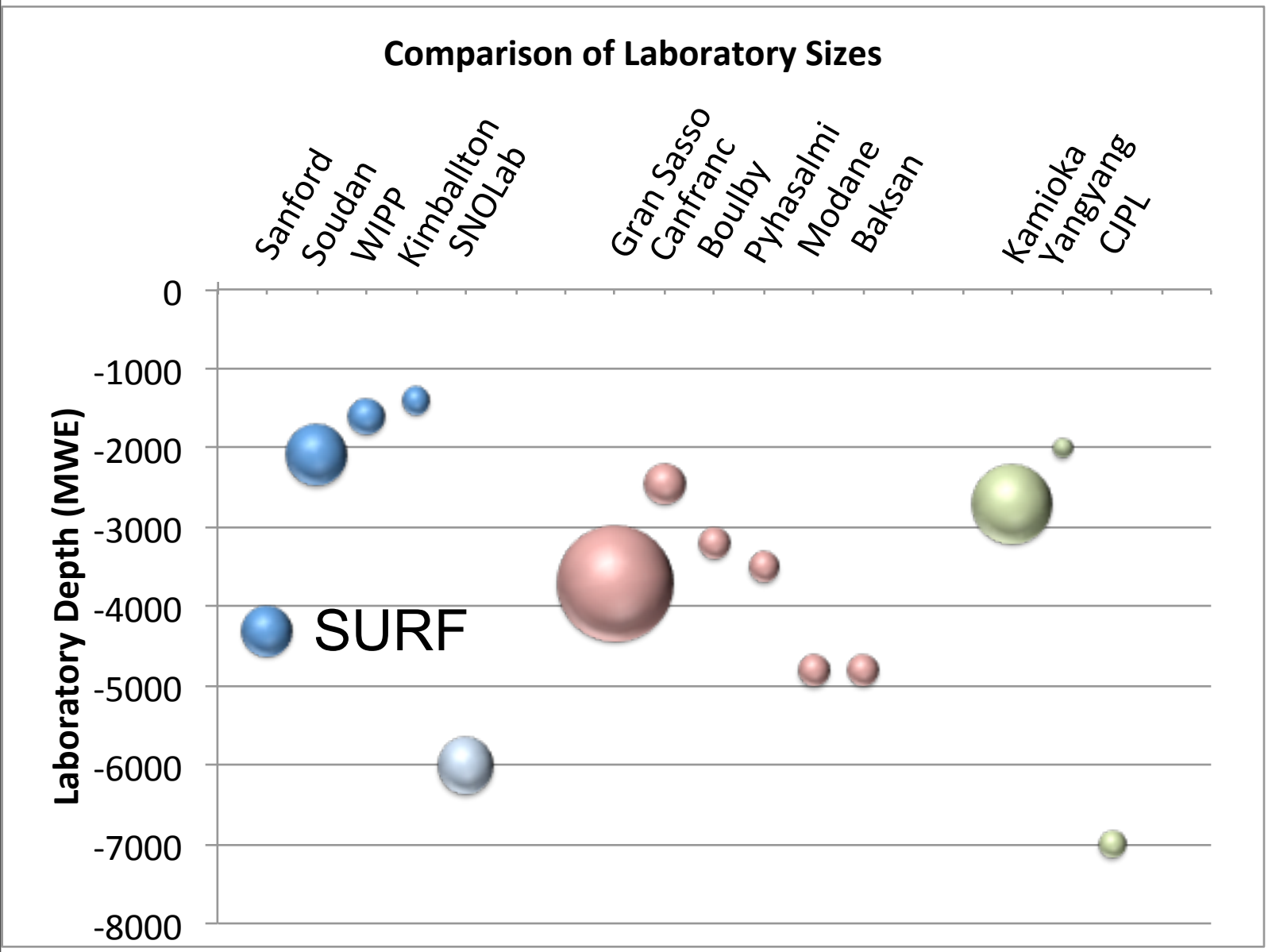
SURF Experiment Integration & Support

- Coordination:
  - *Weekly meetings with individual groups, incl schedule [LUX/MJD]*
  - *Weekly group meeting, incl schedule integration [LUX/MJD/CUBED]*
  - *Weekly Science dept meetings [address all, incl BGE]*
  - *Daily/weekly work plans from individual groups [all, incl BGE]*
  - *Daily coordination meetings at Davis Campus [LUX/MJD/CUBED]*
- Personnel:
  - *Facility Technician (full-time Davis Campus)*
  - *Facility Electrician (full-time Davis Campus, eval for future)*
  - *Experiment Support Scientist (full-time Davis Campus, 1 currently, will increase to 2]*
  - *Laboratory Custodian (full-time Davis Campus)*
  - *Other resources: EHS (incl industrial hygiene, inspections), additional support as needed incl Ops electrical, contractors, etc*
  - *Daily crews: SURF (4-5), LUX (up to 17 so far), MJD (up to 17 so far)*
- Access:
  - *Support 24-hr access, 7 days per week, multiple shifts per day*
  - *Some experiment personnel receive extra training to become "Guides"*

SURF Status Summary

- **Current:**
  - → *16 active research groups:* 9+ research papers (many from the BGE community)
  - → ***LUX:*** Surface Lab occupancy since Dec 2009, stable operations since Dec 2011, installation underground May 2012, detector fill and commissioning February 2013
  - → ***MAJORANA:*** E-forming Lab occupancy since Dec 2010, operational since July 2011, installation in the Davis May 2012, detector construction initiated January 2013
  - → *Interactions continue with other groups, notably LBNE and DIANA*
  - → *Support of existing facilities and activities working well with current resources, Davis Campus completed and certified for scientific occupancy* ✓
  - → *Experiment implementation and EH&S Support:*
    - Includes many facets, include Readiness Reviews
    - Support from entire Lab
  - → *Experiment integration:*
    - Coordination commensurate with activity
    - Other examples: Guide policy, developing Researcher Work policy, Davis Campus training materials
- **Near-Term:**
  - → *Expect continued access to current Lab footprint, including non-4850L levels*
  - → *Davis Campus beneficial occupancy May 2012* ✓
    - Additional engineering support in place to ensure successful integration ✓
    - **Underground installation and Commissioning of LUX and MJD well underway** ✓

SURF in the international context



Status of Sanford Underground Research Facility

Science Personnel

Connie Giroux (BS,MS)– *Laboratory Supervisor*
- Surface / Underground Lab Supervisor (LUX/MJD)

Wendy Zawada (BSMinE)– *Integration Engineer*
- Planning/scheduling/logistics (LUX/MJD)

Mark Hanhardt (MS)– *Experiment Support Scientist*
- Davis Campus science support

David Taylor (BSME,PE)– *Expt Review Engineer*
- Readiness reviews, cryo safety

Robyn Varland– *Lab Custodian*
- Maintain cleanliness at Davis Campus

Jaret Heise (PhD)– *Director*
- Manage science implementation and programs

SURF Science

Implementation Framework

- **Project Documentation:**
  - → *Experimental Planning Statement (update as necessary)*
  - → *Memorandum of Understanding (update as necessary)*
  - → *General Services Agreement (update annually)*
  - → *Insurance*
  - → *Decommissioning Plan*
- **EHS:**
  - → *Critical procedures, hazard analysis, training*
  - → *Chemical, electrical, radioactive source inventories*
- **Review Process:**
  - → ***Small** projects reviewed by Science/EHS + Subject Matter Experts*
  - → ***Large** projects may also be reviewed by panel of experts*
- **Laboratory Integration:**
  - → *Advisory committees, internal evaluation*
  - → *Policies, access, work planning/reporting, use of Lab resources*
- **Authorization To Proceed**
  - → *Lab Management (Headley/Lesko) and/or Science Director and EH&S Director*

SURF Science Implementation

Safety Readiness Reviews

- **LUX:**
  - → *Hazards = pressure, cryogens, electronics, hoisting/rigging, radiation*
  - → ***Surface Operations Readiness Review*** *(Held Nov 2010 + Pre-Readiness Dec 2008)*
    - Chan (chair) + 5 committee members to address formal charge, in-person review
    - Final committee report Dec 2010 with recommendations (followup via reviews, walk-throughs)
  - → ***Davis Campus Readiness Review*** *(Held Oct 2011)*
    - Chan (chair) + 9 committee members (incl external and observers) to address formal charge, in-person review
    - Final committee report Dec 12, 2011 with recommendations
- **MAJORANA DEMONSTRATOR:** update
  - → *Hazards = chemicals, cryogens, pressure, electronics, hoisting, structural, radiation*
  - → ***Ross Campus Electroforming Readiness Review*** *(Held Jan 2011 + Initial Jan 2010)*
    - Kadel (chair) + 5 committee members to address formal charge, in-person review
    - Final committee report Feb 2011 with recommendations (followup via reviews, walk-throughs)
  - → ***Davis Campus Readiness Review*** *(completed January 2012)*
    - Taylor/Garcia-Sciveres (co-chairs) + 8 committee members (incl external and observers) to address formal charge, in-person review
    - Take advantage of MAJORANA internal reviews (eg., pressure, ODH, structural)
    - Initial draft of committee report received Feb 17, 2012 (finalize shortly afterward)

SURF Experiment Support

Participation From All Departments

- **Science:**
  - → *Main point of contact, coordinate with other depts, direct supervision, etc*
- **Operations:**
  - → *Maintain and provide access to Laboratory (surface and underground):*
    - Hazard mitigation, site prep (and related technical advice to science groups)
    - Installation and maintenance, incl filters and services (power, network)
    - Equipment and personnel transportation, etc (incl fabrication)
- **EH&S:**
  - → *Policies, guidelines, forms (eg., Action Plan, Job Hazard Analysis, etc)*
  - → *Safety resource (eg., training, inspections, monitoring, waste, reviews, etc)*
- **Engineering (incl Systems Engineering):**
  - → *Lab development, contract support*
  - → *Engineering assessments incl hazard mitigation, Safety Readiness reviews (incl tracking recommendations)*
- **Administration (incl IT, Project Controls, Communications, E&O):**
  - → *Shipping and receiving, event planning, badging, IT, PDA compliance*
  - → *Schedule development and tracking*
  - → *Public outreach, showcase science and scientists locally, state, national*

SURF Science Implementation

Integration: Policies

- **EHS Policies:**
  - → *General:*
    - Work planning and hazard analysis, “Stop Work”, etc
    - Laboratory Access (max underground occupancy currently 52 people)
  - → *Section 8000: Science Safety:*
    - Expt review thresholds, cryo systems review, ODH analysis, etc
- **Experiment Implementation Policy:**
  - → *Documentation, EHS, training, reviews, integration, authorization*
- **Researcher Work Policy (mainly surface, updating for underground):**
  - → *Daily/Weekly work plans*
  - → *Lab access outside regular business hours (surface)*
  - → *No working alone in Laboratory space*
- **Laboratory Guide Policy:**
  - → *Sets guide ratios (in most underground areas ratio = 4:1 visitor-to-guide)*
  - → *Defines baseline “Guide” requirements, “Knowledgeable Person” (trainer)*
  - → *Defines “Designated Lab” space, minimum 1 guide*

SURF Experiment Integration & Support

- Coordination:
  - *Weekly meetings with individual groups, incl schedule [LUX/MJD]*
  - *Weekly group meeting, incl schedule integration [LUX/MJD/CUBED]*
  - *Weekly Science dept meetings [address all, incl BGE]*
  - *Daily/weekly work plans from individual groups [all, incl BGE]*
  - *Daily coordination meetings at Davis Campus [LUX/MJD/CUBED]*
- Personnel:
  - *Facility Technician (full-time Davis Campus)*
  - *Facility Electrician (full-time Davis Campus, eval for future)*
  - *Experiment Support Scientist (full-time Davis Campus, 1 currently, will increase to 2]*
  - *Laboratory Custodian (full-time Davis Campus)*
  - *Other resources: EHS (incl industrial hygiene, inspections), additional support as needed incl Ops electrical, contractors, etc*
  - *Daily crews: SURF (4-5), LUX (up to 17 so far), MJD (up to 17 so far)*
- Access:
  - *Support 24-hr access, 7 days per week, multiple shifts per day*
  - *Some experiment personnel receive extra training to become "Guides"*